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SURFACE FINISH AUGMENTATION OF BORING OPERATION USING IMPACT DAMPERS

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ABSTRACT

In the field of manufacturing industries, many new concepts and techniques have been introduced to improve its performance and adaptability to the international standards. In industries, boring operation suffer vibrations due to high over hang of the tool. In this study, improvement of the damping capability of boring tools is attempted using impact dampers. The technique is attempted to reduce the chatter in boring tool and thereby study improvement in surface finish. Slight structural alteration are done to the boring bar and then the effect of Impact Dampers, the overhang length of the boring tools and their cutting conditions on surface finish is studied. Theoretical and practical results are verified using regression analysis.

KEYWORDS: Boring tool, Impact Damper, Surface Finish, Regression Analysis.

1. Introduction

Boring is an operation that enlarges and improves the accuracy of an existing hole. Either the work or the cutting tool rotates about the centre axis of the hole. The single point tool describes a circle, removing material from the surface of the existing hole as it advances, enlarging the hole, and normally increasing the precision of any of a number of factors. They are: its location, diameter, direction, cylindricity, and finish. Generally, boring operations are expected to be able to hold ± 0.001 in location and as good as a 32 µin surface finish, although greater tolerances can be had with extra care. When this operation is performed on a boring machine, the workpiece is stationary and the cutting tool rotates; when performed on a lathe, the workpiece rotates. On a lathe, the operation can then be considered to be internal turning. The tool spindle and the workpiece holder must be rigid enough to provide the desired accuracy in the bored hole. The operation is performed on holes from about ¼ in (6 mm) in diameter and larger but is more common on larger holes, especially those too large to be drilled accurately, and for the machining of cast or forged large holes [5] [Smith] Boring a hole will achieve several distinct production criteria:

- Boring is often a finishing operation in which the depth of cut is limited. Surface finish requirements may dictate faster cutting speeds, slower feed rates, and smaller nose radius.

- Chip control in the confines of a bore must be considered.

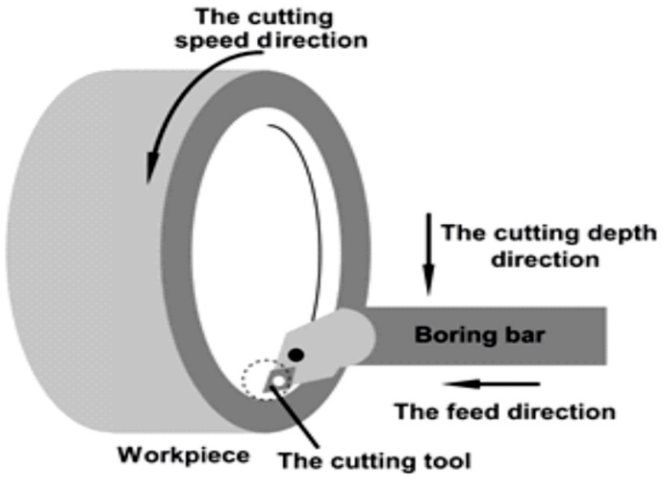

FIGURE 1.1 Boring Operation

A schematic picture of a cutting operation using a boring bar can be seen in Fig. 1.1. The actual cutting is performed at the cutting tool mounted at the tip of the boring bar. During a cutting operation the boring bar is fed in the feed direction at a specific cutting depth and a specific rotational speed of the workpiece. The vibration of the boring bar is influenced by three parameters, feed rate, cutting depth and cutting speed. The vibrations in the boring bar are in the cutting speed and the cutting depth direction.

2. Objective of Proposed Work

- The major objective of the proposed research work is to enhance the surface finish of machined surface obtained by boring operation.

- It is also planned to develop a cutting tool (boring bar) inherently having a damper, which can suppress the vibrations generated during the machining operation.

- To develop a mathematical model for optimized machining conditions, this gives a better surface finish for different machining parameters.

3. Methodology

For conducting any successful experiment, there is a requirement of rigorous planning and background study of the subject. From the understanding of basics of manufacturing and literature review of past and present research, a problem is clearly defined. From the problem definition it is observed that, vibration created due to large overhang and smaller cross-section of the boring bar the surface finish obtained after machining is poor. The today's industry requirement is to achieve good surface finish to meet the customers' quality requirements. It is planned to use a passive technique of vibration isolation so that much cost will not be involved.

3.1 CNC Machine

To eliminate the inherent vibrations of the general purpose lathe machine, the boring operations were carried out on the rigidly mounted and regularly maintained and reliable CNC turning centre of ACE (JOBBER XL Horizontal Lathe) make.

3.2 Boring Bar

The boring tools used in this experiment are specially manufactured and have a section of 20x20 mm and an overall length of 200 mm as shown in Figure 3.3. On the other hand, in many boring tools on the market, when dimensions of a section are about 20x20mm, the overall length could be about 180 mm (overhang length 40-80–120mm). However, in order to investigate the relationships between the overhang length of boring tools and vibration suppression effects of the impact dampers, boring tools with a fairly long overall length were used in this experiment and compared with boring tools on the market. All dimensions of these boring tools are identical.

FIGURE 3.1: Customized Boring Bar for Vertical Mass (WIDAX S20R STUNL 16F3 MAKE)

FIGURE 3.2: Impact Damper mounted in vertical position on boring bar (Brass Length -21mm Diameter – 10mm)

3.3 Insert

Cermets are cemented carbides, in which titanium carbonitride (TiCN) is used to provide the majority of the hardness instead of tungsten carbide, and a compound of nickel and cobalt serves as the binder. This difference in composition makes the cermets more heat resistant, on the one hand. On the other hand, it diminishes the material's toughness. They are capable of running at moderate to high speeds and are best used with light feeds and depths of cut. They feature excellent abrasion resistance and thermal properties, as well as lubricity for crater resistance.

FIGURE 3.3: Insert mounted on Boring Bar (Widia make Material: Cermets, Dimensions 0.8mm)

3.4 Workpiece

EN9 is used as work piece (25 nos.) Material for conducting the experiments.

FIGURE 3.4: Semi-finished (made true) work-pieces

3.5 Surface Roughness Tester

MITUTOYO SJ 201-P was used to measure the roughness value.

4. Observation Tables

(I) Without Impact Mass (Standard Boring Bar)

Speed: 240 rpm (maximum speed)

Depth of Cut: 0.6 mm

Feed: 0.09 mm/rev

Table 4.1: Observation Table

Sr. No.	Test No.	Overhang Length(mm)	Response (Surface finish Ra in µm)		
			1	2	3
1	1	40	2.72	2.89	3.05
2	2	80	8.62	8.91	9.1
3	3	120	10.9	11.1	11.2

(II) With Impact Mass (Customized Boring Bar)
SINGLE IMAPCT MASS

Boring bar overhang length: 40 mm,

Depth of Cut: 0.6 mm

Feed: 0.09 mm/rev

Impact Mass Location: Vertical

Table 4.2: Observation Table

Sr. No.	Test No.	Speed (rpm)	Response (Surface finish Ra in µm)		
			1	2	3
1	4	80	2.21	2.20	2.29
2	5	160	2.38	2.41	2.33
3	6	240	2.44	2.50	2.56

Boring bar overhang length: 80 mm,

Depth of Cut: 0.6 mm
Feed: 0.09 mm/rev

Impact Mass Location: Vertical

Table 4.3: Observation Table

Sr. No.	Test No.	Speed (rpm)	Response (Surface finish Ra in µm)		
			1	2	3
1	7	80	4.89	4.92	4.78
2	8	160	4.76	4.82	4.80
3	9	240	4.67	4.55	4.62

Boring bar overhang length: 120 mm,

Depth of Cut: 0.6 mm

Feed: 0.09 mm/rev

Impact Mass Location: Vertical

Table 4.4: Observation Table

Sr. No.	Test No.	Speed (rpm)	Response (Surface finish Ra in µm)		
			1	2	3
1	10	80	6.04	5.98	5.87
2	11	160	5.90	5.92	5.78
3	12	240	5.02	4.98	4.89

5. Result Analysis and Discussion

5.1 Result Analysis

From the results obtained after conducting the experiments, which are arranged in different observation tables were used for analysis so that meaningful inference about the research work can be made.

5.2 Multiple Regression Analysis

Multiple regression analysis is used to test the effects of independent (predictor) variables on a single dependent (criterion) variable. Regression tests the deviation about the means, and all variables must be at least interval scaled. Computationally, regression analysis may be conducted using either a raw data matrix (respondents by variables) or a correlation matrix. For exercising the regression analysis proven statistical software Minitab® Rel.15 is used.

Single Impact mass attached in vertical position

Table No 5.1: Data in the coded format

Coded form	Average Response	
Boring Bar Overhang	Spindle Speed	Surface Roughness (µm)
X1	X2	Y
-1	-1	2.233333
-1	0	2.373333
-1	+1	2.5
0	-1	4.863333
0	0	4.793333
0	+1	4.613333
+1	-1	5.963333
+1	0	5.866667
+1	+1	4.963333

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Regression Analysis: Surface Roug versus Boring Bar O, Spindle Speed

The regression equation is
Surface Roughness(μm) = 1.34 + 0.0404 Boring Bar Overhang(mm)
- 0.00205 Spindle Speed (rpm)

Predictor	Coef	SE Coef	T	P
Constant	1.3400	0.6420	2.09	0.082
Boring Bar Overhang (mm)	0.040361	0.005452	7.40	0.000
Spindle Speed (rpm)	-0.002049	0.002726	-0.75	0.481

S = 0.534203 R-Sq = 90.2% R-Sq(adj) = 87.0%

Generalized regression equation;
Surface Roughness (Ra (μm)) =
1.34 + 0.0403 (Boring Bar Overhang (mm)) - 0.00205 (Spindle Speed (rpm))
R-Square, also known as Coefficient of Regression is a commonly used statistic to evaluate model fit. R-square is 1 minus the ratio of residual variability. When the variability of the residual values around the regression line relative to the overall variability is small, the predictions from the regression equation are good.

R-Square = 90.2%

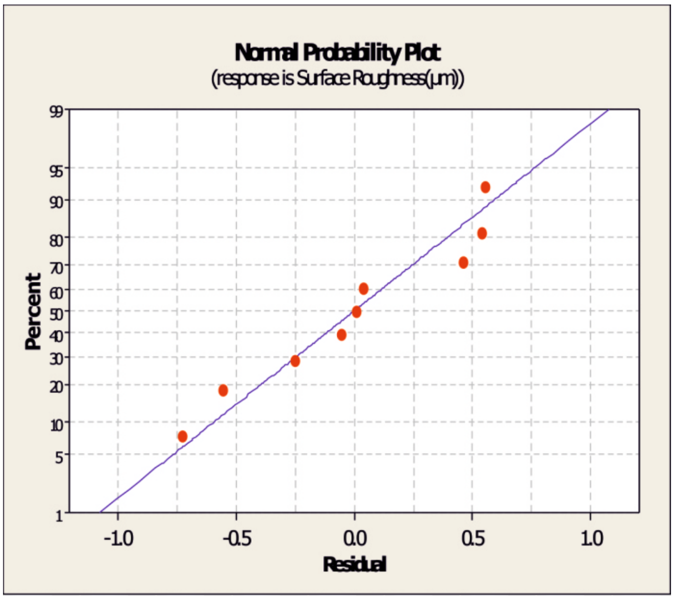

Figure 5.3: Plot for Single Impact mass attached in vertical position

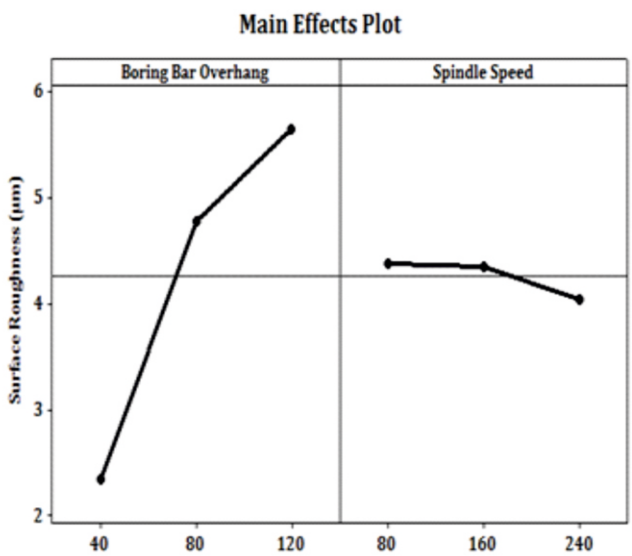

Figure 5.4: Main Effects Plot for Single Impact mass attached in vertical position

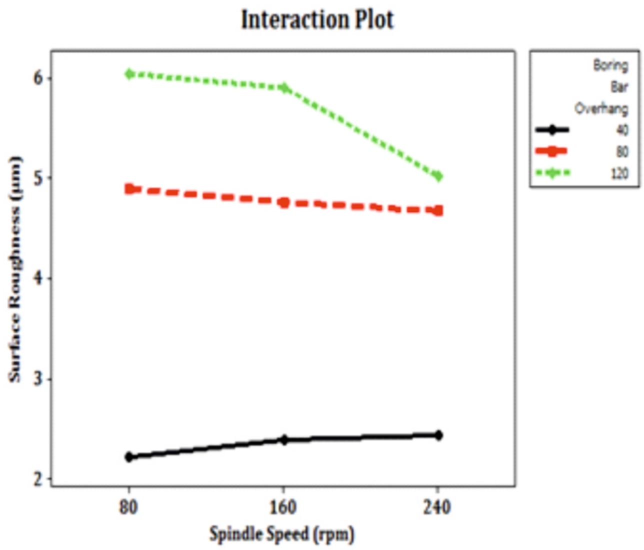

Figure 5.5: Interaction Plot for Single Impact mass attached in vertical position

5.3 Confirmation Tests
When the analysis of the experiment is complete, one must verify that the predictions are good. These are called confirmation runs. The interpretation and conclusions from an experiment may include a "best" setting to use to meet the goals of the experiment. Even if this "best" setting were included in the design, you should run it again as part of the confirmation runs to make sure nothing has changed and that the response values are close to their predicted values would get.

Confirmation Test for Generalized Regression Equation

Table No. 5.1: Process Parameters

Overhang Length	80 mm
Spindle Speed	120 rpm

Ra = 1.34 + 0.0403(80) -0.00205(120)

Ra (Th) = 4.31μm

Ra (Pr) = 4.29μm

The surface finish obtained is 4.29 μm, which is closely matching with the value obtained by regression equation i.e. 4.31 μm.

5.4 Result Table

Table No. 5.2: Result Table

Impact Damper	Damper Position	Ra(μm) (Th)	Ra(μm) (Pr)
Single	Vertical	4.31	4.29

6. Conclusion
A rigorous full factorial experimentation for boring operations for different parameters and variables was conducted. These experiments were performed on well-maintained CNC turning centre mounted on robust foundation so that the machine itself is free from vibration. The boring bar and insert were used are standard and of the reputed make and manufacture used normally for routine machining operations in the industries. All these operations were carried out under the supervision of skilled CNC operator. The Mitutoyo SJ-201P apparatus used for surface roughness measurement is calibrated. All the possible measures were taken for unbiased experimentation.

From the experimental results following points were clarified.
1. The damping capability of boring tools is considerably improved using impact dampers.

2. Impact damper used in the experiment can suppress considerably the vibration of boring tools and helps to enhance the surface finish of the machined surface.
3. Using an impact damper, it is possible to bore deeper holes in comparison with standard boring tools (without dampers) available in the market and to improve the efficiency and productivity of boring operations.

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